FUNCTIONAL OUTCOME OF LOCKING COMPRESSION PLATING FOR CLOSED SCHATZKER TYPE V AND TYPE VI TIBIAL PLATEAU FRACTURES. A PROSPECTIVE STUDY

Dissertation submitted for

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CERTIFICATE

Certified that this dissertation titled '**Functional Outcome Of Locking Compression Plating for Closed Schatzker type V and Type VI Tibial Plateau Fractures-A Prospective Study"** is a bonafide work done by Dr. C. KARTHIKEYAN, at Government Thanjavur Medical College between 2008- 2011, under my guidance and supervision .

This dissertation is submitted to Tamil Nadu Dr. M. G. R. Medical University, towards partial fulfillment of regulation for the award of M. S. Degree (Branch-II) on Orthopaedic Surgery.

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DECLARATION

I, solemnly declare that this dissertation '**Functional Outcome Of Locking Compression Plating for Closed Schatzker type V and Type VI Tibial Plateau Fractures -A Prospective Study.**' is a bonafide work done by me, at Government Thanjavur Medical College and Hospital between 2008- 2011, under the guidance and supervision of **Prof. Dr. M. Gulam Mohideen, M.S. (Ortho), D. Ortho.,** Professor and Head of the Department of Orthopaedic surgery.

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Place: Thanjavur

Date:

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CONTENTS

INTRODUCTION

Knee is a major weight bearing joint of the lower limb consequently any fractures involving the proximal tibia will definitely compromise the knee function and stability. They account for only for 1% of all fractures and 8% of fractures in the elderly[1]. Tibial plateau fractures are frequently caused by high energy trauma and 1 to 3 % of these fractures are open injuries, often associated with other complications[1] .Isolated injuries to lateral condyle occur in 70%, 15% involve medial condyle, and 15% are bicondylar[1]. Though difficult, the aim of treatment of these fractures is to bring back and conserve normal knee function by anatomical restoration of joint surfaces, maintaining of mechanical axis and restoring ligamentous stability. Understanding the injury patterns, better implants, and the concept of early surgical fixation and early mobilization of knee joint all have convincingly bettered the functional outcome of these injuries to a great degree. Historically we have seen immobilization for 6 weeks in traction or plaster immobilization causing stiffness. If operated with extensive dissection for the purpose of reduction it resulted is delayed union and infection. This forms the cause of evolving an in between approach, [Minimally invasive approach] [2] which not only reduces stiffness but is also biological. The locking screw technology was initiated by Carl Hansmann [Hamburg 1886] [3]and improved by Paul Reinhold [Paris 1931]. But now Locked plate technology has become the latest innovation, which is widely used in managing complex tibial plateau fractures. With the advent of newer implants and minimally invasive techniques, complex tibial plateau fractures which were once considered difficult to treat, are now having successful outcomes.

AIM

The aim is to study the **“functional outcome of treatment of closed schatzker type v and type vi tibial plateau fractures using locking compression plate”** at the Department of Orthopaedics and Traumatology, Thanjavur Medical College, Thanjavur.

REVIEW OF LITERATURE

Treatment of tibial plateau fractures is probably the perfect example of how fracture treatment has evolved in the past century. In the beginning there was closed reduction and immobilization with cast, then came the era of internal fixation with Buttress plates, where the emphasis was on anatomical reduction and rigid fixation, then along came the modalities of external fixation using hybrid fixators and Ilizarov fixators.

Now in the twenty first century, where the principles of biological fixation are in the forefront, it is well emphasized that in treatment of tibial plateau fractures locking compression plate has a definite role. The combination of biological fixation and angular stable implants has revolutionized the treatment of tibial plateau fractures.

Silver plates and galvanized steel screws were first used in the operative treatment of plateau fractures in 1900 by Stitchbach.

Conservative treatment was proposed for tibial plateau fractures when there were no strong internal fixation devices available by Apley 1956 [4], Dovey and Heerfordt 1971, Drennan , Locher and Maylahn 1979, Marwah, Gadegone and Magarkar 1985. But as late as 1990 Jensen, Rude and Duus [5] in their work have concluded that conservative treatment is a valid alternative to surgery but probably should be reserved for cases where surgery is undesirable.

Surgical treatment with anatomical restoration of joint surfaces was recommended by various authors like Leadbetter and Hand 1940 [7], Schatzker et al 1979 [6], Blokker, Rorabeck, Bourne 1984, Holz et al 1985.

1980 Mitchell and Shepherd showed that accurate reduction and stable fixation of intraarticular fragments is needed for cartilage regeneration and that malreduction and instability results in rapid articular cartilage degeneration.

Schatzker, Mcbrom and Bruce [1979] [6] emphasized the importance of early knee movements in successful outcomes after treatment.

These findings further emphasized the need for open reduction and rigid internal fixation and also the need for implants which provided adequate stability and a minimally invasive approach.

Marsh et al 1995 [8], Morandi et al 1994, Dendrinos et al 1996 [9] advocated the use of external fixator in treatment of tibial plateau fractures. Malik et al 1992 [10] compared the use of internal versus external fixation in the treatment of tibial plateau fractures and showed comparable results. The development of the LCP, which has been available for clinical use since 2001, has revolutionized internal plate fixation, as this system combines two different principles of internal fixation, Niemeyer,Sudkamp. 2006 [11].Stannard [12] et al, Cole [13] et al, Ricci et al 2004 in their series on minimally invasive techiques for treatment of tibial plateau fractures have shown excellent results. In 2005 Gosling T., Schandelmaier [14] advocated the use of Single Lateral Locked Screw Plating of Bicondylar Tibial Plateau Fractures.

Rasmussen [15] in 1973 after his extensive analysis on tibial plateau fractures has proposed the score for assessing the functional outcome after treatment of tibial plateau fractures.

Bostman [16,] Kiviluoto 1981 have proposed the Bostman knee score for functional outcome following patellar fractures.

Thus we see how management of tibial plateau fractures have evolved from a period of closed reduction and casting to that of internal fixation with plates to that of biological fixation with locking compression plates.

Table 1.shows the evolution of plating technology

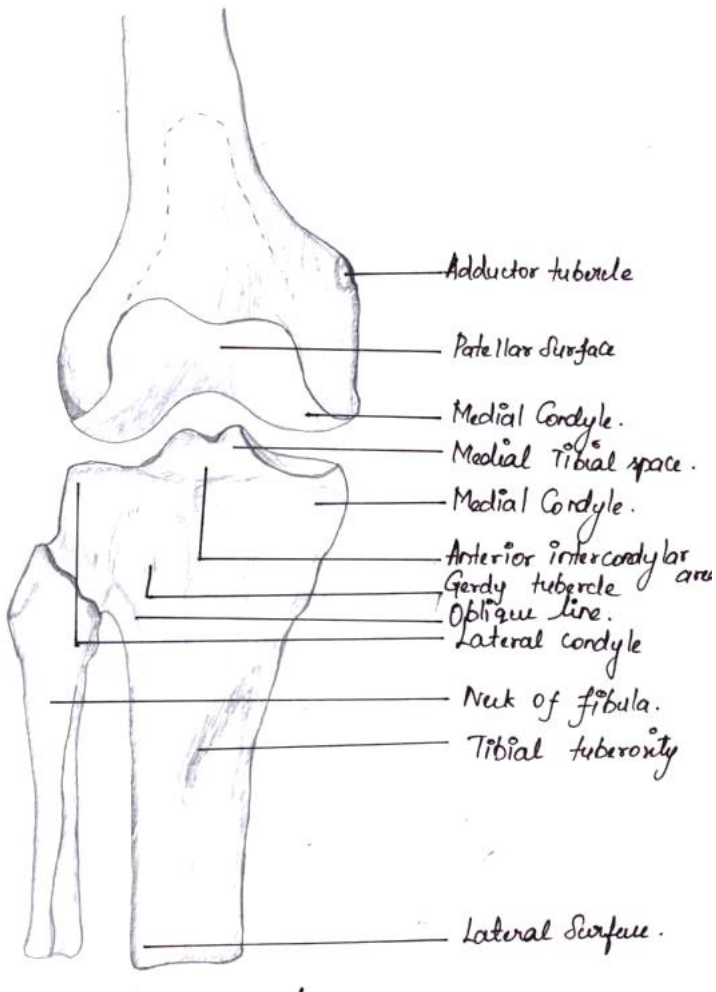
Table 1. [17]

Year	Implant	Author
1886	First internal fixation with a plate	Hansmann in Hamburg
1961	Round hole plates	Maurice Müller
1963	Tubular plates	Maurice Müller
1970	Dynamic compression plates	Stephan Perren
1989	Indirect reduction techniques	Jeff Mast
1990	Biological fixation	Reinhold Ganz
1991	Limited contact (DC) plates	Stephan Perren
1993	PC-Fix	Stephan Perren
1997	MIPO	Christian Krettek
1995	LISS	Robert Frigg
2000	Locking compression plates (LCP)	Robert Frigg, Michael Wagner
2008	Locking compression plates (LCP) for type 5 and 6 schatzker tibial plateau fractures.	Fabio Castelli [18]

THE TIBIAL PLATEAU- ANATOMY [19]

The tibial plateau constitutes the expanded proximal end of tibia which is the bearing surface for body weight transmitted through the femur. It has medial and lateral condyles, an intercondylar area and a tibial tuberosity. The tibial condyles overhang the proximal posterior surface of the shaft. The condyles are visible and palpable at the sides of the patellar tendon, the lateral being more prominent. Lateral condyle is grooved posteriorly by the tendon of popliteus, with a synovial recess between the tendon and bone. The anterolateral aspect of the condyle has a sharp margin for the attachment of deep fascia. The distal attachment of the iliotibial tract makes a marking on its anterior aspect called the Gerdy's tubercle. Articular surface of the proximal tibia slopes posteriorly and downwards relative to the long axis of the shaft. The medial articular surface is oval (long axis anteroposterior) and longer than the lateral tibial condyle. It’s anterior, medial, and posterior margins are related to the medial meniscus, the surface is flat in the posterior half with the more anterior surface sloping upwards around 10°. Much of the posterior surface is covered by the meniscus, so that overall a concave surface is presented to the medial femoral condyle. Its lateral margin is

ANTERIOR VIEW OF KNEE JOINT



Anterior View of Knee

raised as it reaches the intercondylar region. The lateral articular surface is more circular and adapted to its meniscus. In the sagittal plane the articular surface is flat centrally and falls away inferorly, anteriorly and posteriorly creating a convex surface. So when the lateral femoral condyle is in contact, there are anterior and posterior recesses (of triangular section), which are occupied by the anterior and posterior meniscal horns. Its articular margins are sharp, except posterolaterally, where the edge is round and smooth here the tendon of popliteus is in contact with bone.

Intercondylar area is the rough-surfaced area between the condylar articular surfaces. It is narrow centrally with an intercondylar eminence, consisting the lateral and medial intercondylar tubercles. The intercondylar area is widest anteriorly. Anteromedially, is a depression where anterior horn of the medial meniscus is attached. Behind this it receives the anterior cruciate ligament, lateral to it is attached the anterior horn of the lateral meniscus. The posterior horn of the lateral meniscus is attached to the posterior slope of the intercondylar area, behind it in a depression is attached the posterior horn of the medial meniscus. The rest of the area is smooth and provides attachment for the posterior cruciate ligament, spreading back to a ridge for the capsular ligament.

Soft tissues and ligaments:

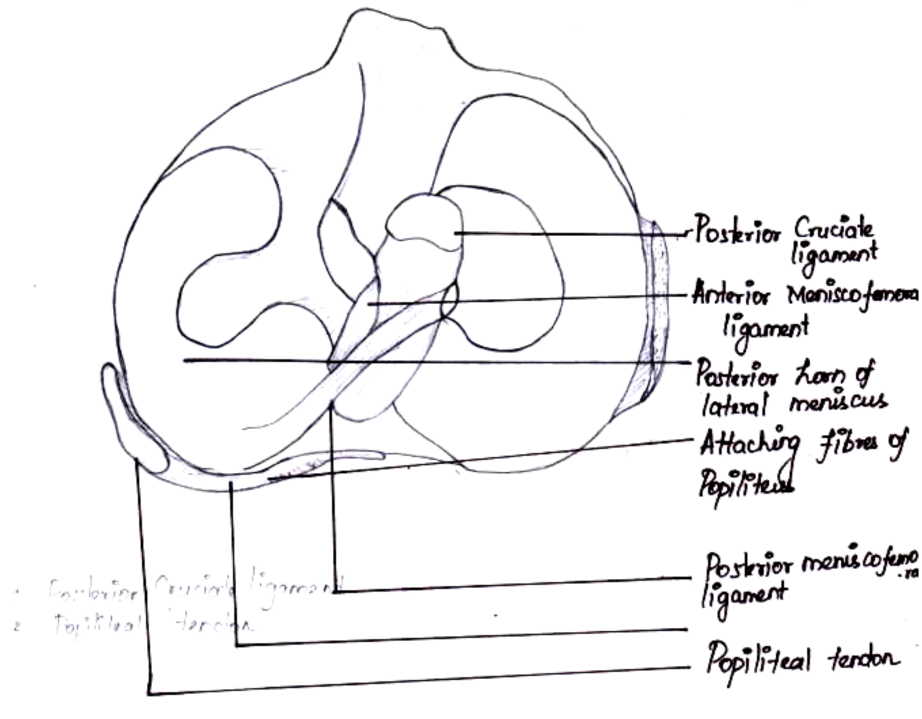
Medial meniscus:

This is broader posteriorly, is semicircle in shape. It is attached by its anterior horn to the intercondylar area in front of the anterior cruciate ligament. The posterior horn is fixed to the posterior tibial intercondylar area, between the attachments of the lateral meniscus and posterior cruciate ligament. Its peripheral border is attached to the fibrous capsule and the deep surface of the medial collateral ligament. The tibial attachment is known as the **'coronary ligament'**. Collectively these attachments ensure that the medial meniscus is relatively fixed and moves much less than the lateral meniscus.

Lateral meniscus:

This forms approximately four-fifths of a circle, and covers a larger area than the medial meniscus. It is grooved posterolaterally by the popliteal tendon, which separates it from the fibular collateral ligament. Its anterior horn is attached in front of the intercondylar eminence, posterolateral to the anterior cruciate ligament. Its posterior horn is attached in front of the posterior horn of the medial meniscus. Its anterior attachment is twisted with its free margin facing posterosuperiorly, Near its posterior attachment it

SUPERIOR VIEW OF TIBIAL CONDYLES



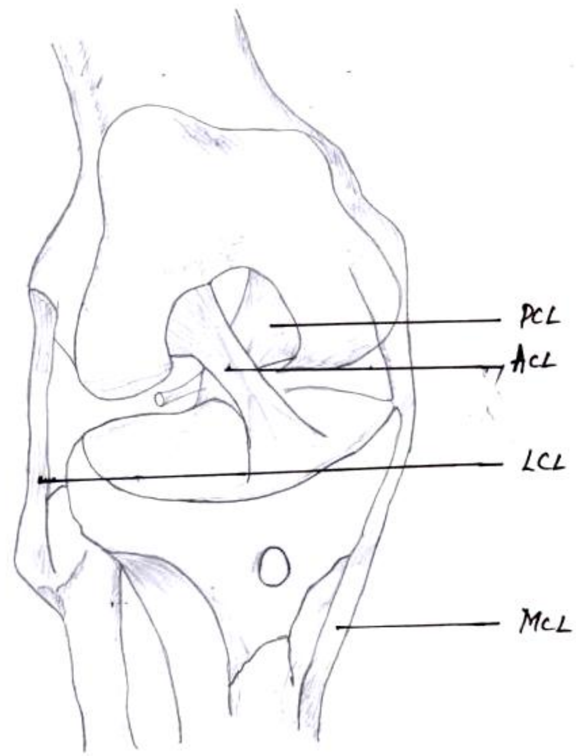
commonly sends a **posterior meniscofemoral ligament** behind the posterior cruciate ligament to the medial femoral condyle. An anterior meniscofemoral ligament may also connect the posterior horn to the medial femoral condyle anterior to the posterior cruciate ligament. More medially, part of the tendon of popliteus is attached to the lateral meniscus. A meniscofibular ligament occurs in 80% of knee joints [19e]. There is a tibial attachment via a coronary ligament, but the meniscus has no peripheral attachment in the region of popliteus, the popliteus hiatus.

Ligaments:

Anterior cruciate ligament: This is attached to the anterior intercondylar area of the tibia, just anterior and slightly lateral to the medial tibial eminence, partly blending with the anterior horn of the lateral meniscus. It ascends posterolaterally, twisting on itself and fanning out to attach high on the posteromedial aspect of the lateral femoral condyle [19c] .Its average length is 38 mm, and average width is 11 mm. It is formed of two, or possibly three, functional bundles. They are named anteromedial, intermediate, and posterolateral, according to their tibial attachments [19d].

Posterior cruciate ligament: This is thicker and stronger than the anterior cruciate ligament. Its average length is 38 mm and average width is 13 mm.

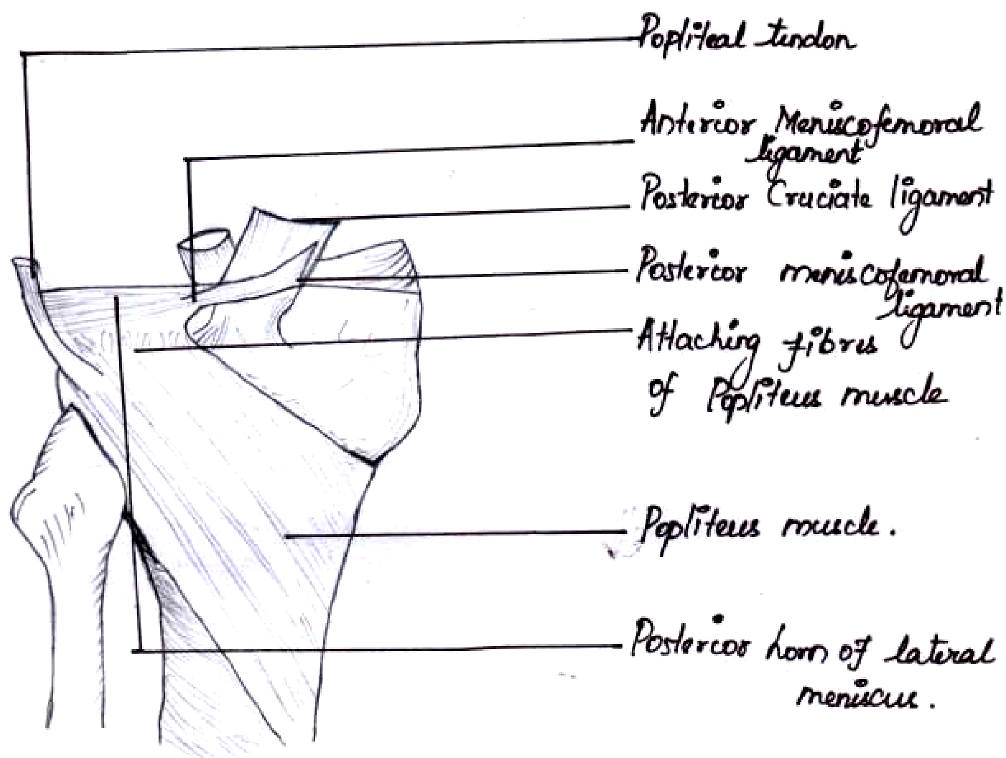
LIGAMENTS OF KNEE IN NEUTRAL ROTATION



Neutral rotation. .

The posterior cruciate ligament is attached to the lateral surface of the medial femoral condyle and extends up onto the anterior part of the roof of the intercondylar notch, where its attachment is extensive in the anteroposterior direction. They pass distally and posteriorly to a fairly compact attachment posteriorly in the intercondylar region and in a depression on the adjacent posterior tibia. This gives a fan-like structure in which fibre orientation is variable. Anterolateral and posteromedial bundles have been defined: they are named (against convention) according to their femoral attachments. The anterolateral bundle tightens in flexion while the posteromedial is tight in extension of the knee. Each bundle slackens as the other tightens. Unlike the anterior cruciate ligament, it is not isometric during knee motion, i.e. the distance between attachments varies with knee position.

POSTERIOR VIEW OF KNEE



Medial soft tissues of knee:

Medial soft tissues consist of three layers[19a].

Layer 1 – invests around the Sartorius tendon

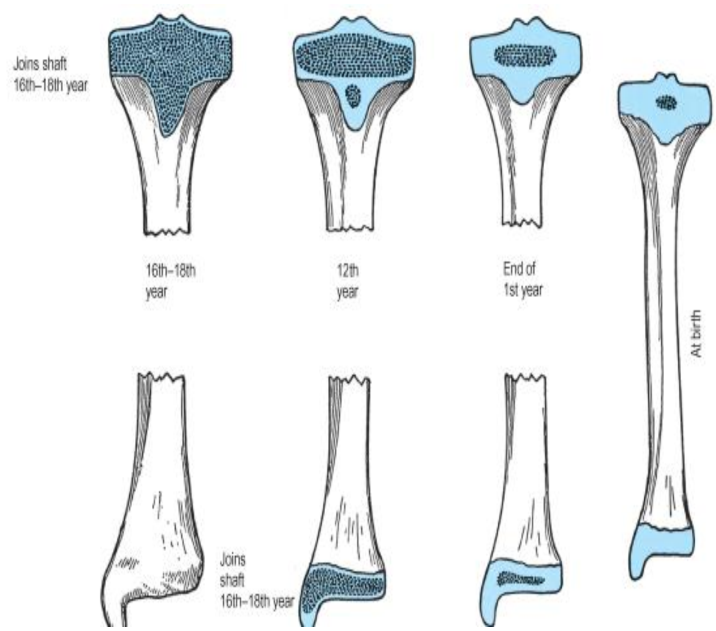
Layer 2 - has the superficial medial collateral ligament which has parallel and oblique portions. The former contains vertically orientated fibres that pass from the medial epicondyle of the femur to a large insertion on the medial tibia 5 cm distal to the joint line. The posterior oblique fibres run posteroinferiorly from the medial epicondyle of the femur to blend with the underlying capsule, effectively to insert on the posteromedial tibial articular margin and posterior horn of the medial meniscus

Layer 3 - 'Layer 3' is the capsule of the knee joint, found deep to the superficial medial collateral ligament it is thick and has vertically orientated fibres that make up the deep medial collateral ligament.

Lateral soft tissues of knee:

The lateral soft tissues are also arranged in three layers[19b]. Most superficial is the lateral patellar retinaculum. The middle layer consists of the lateral collateral ligament, popliteofibular ligament, fabellofibular ligament and arcuate ligament. The deep layer is the lateral capsule.

OSSIFICATION OF TIBIA



The lateral collateral ligament arises from the lateral epicondyle of the femur posterior to the popliteus insertion and just proximal to the popliteus groove. It is a cord like structure that passes distally superficial to the popliteus tendon and deep to the lateral retinaculum, to the fibula, where it blends with the biceps tendon just anterior to the apex of the fibular head. It is separated from the capsule by a thin layer of fat and the inferior lateral genicular vessels.

Ossification of tibia [19] :

The tibia is ossified from three centers one for the body and one for each epiphysis. Ossification begins in the region of midshaft, about the seventh week of fetal life, and gradually extends toward the extremities. The center for the upper epiphysis appears before or shortly after birth, it is flattened in form, and has a thin tongue-shaped process in front, which forms the tuberosity. The center for the lower epiphysis appears in the second year. The lower epiphysis joins the body at eighteen years, and the upper one joins around the twentieth year. Two additional centers occasionally exist, one for the tongue shaped process of the upper epiphysis, which forms the tuberosity, and one for the medial malleolus.

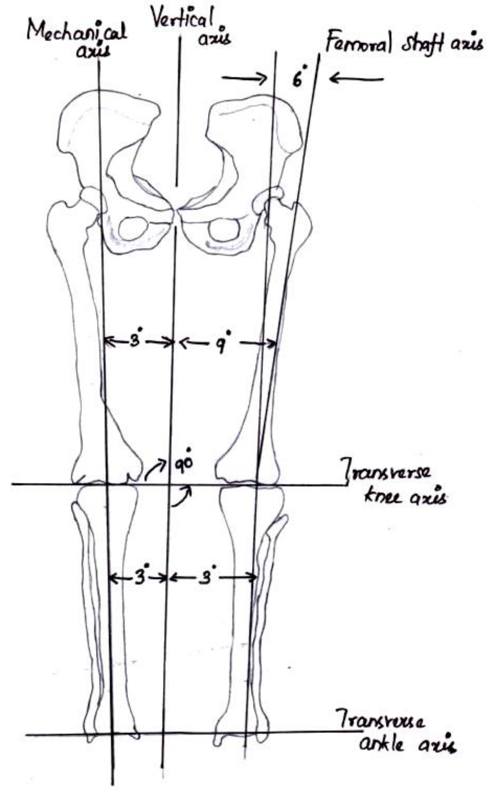
BIOMECHANICS OF KNEE[20]

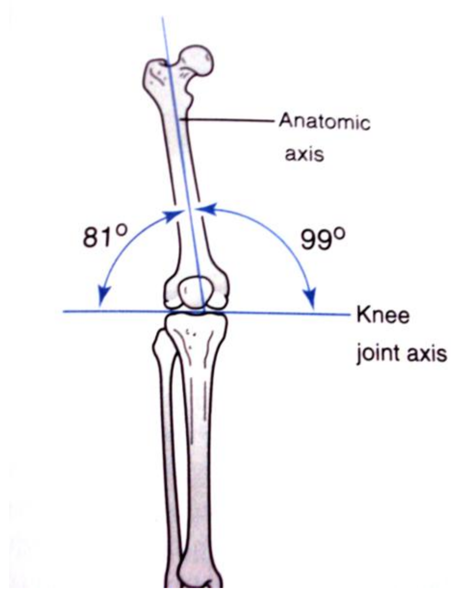
Knee joint axis is parallel to the ground and the anatomical axis is 9 ° valgus to the knee. During weight bearing, the two femoral condyles rest on the horizontal plane of tibial condyles and shaft of femur inclines downwards and inwards.

The longitudinal axis of the diaphysis of the femur inclines medially downward, with an angle of 9° from vertical. The mechanical axis of the femur formed by a line between centres of hip and knee joint is 3° from vertical. Therefore the long axis of the shaft of femur is inclined at an angle to the long axis of the shaft of tibia. This tibiofemoral shaft angle is called as the physiological valgus.

The axis at which flexion and extension occurs shifts backwards in relation to tibia with increasing flexion[21]. However it lies approximately along the line joining the femoral epicondyles. The knee joint possesses features characteristic of both hinge and a pivot joint. The joint permits flexion and extension in the sagittal plane and some degree of rotation when the joint is flexed. The complex flexion-extension motion is a rocking and gliding movement.

ALIGNMENT OF LOWER EXTREMITY





The natural deflection outwards of the tibia on the femur at the knee joint produces greater weight bearing stresses on lateral tibial condyle than the medial condyle, but because the medial condyle is prolonged further forward than the lateral condyle, the vertical axis of rotation falls in a plane nearer the medial condyle.

MECHANISM OF INJURY [22]

Fractures of the tibial plateau are usually caused by high energy mechanisms like, Pedestrian vs car bumper accidents, (fender fracture), high speed motor vehicle accidents, falls from height.

Forces: may be

1. Direct axial compression, with valgus force (more common)

   Rarely with varus force,

2. Indirect shear forces.

The direction, magnitude, and location of the force, as well as the position of the knee at impact, determine the fracture pattern, location, and degree of displacement.

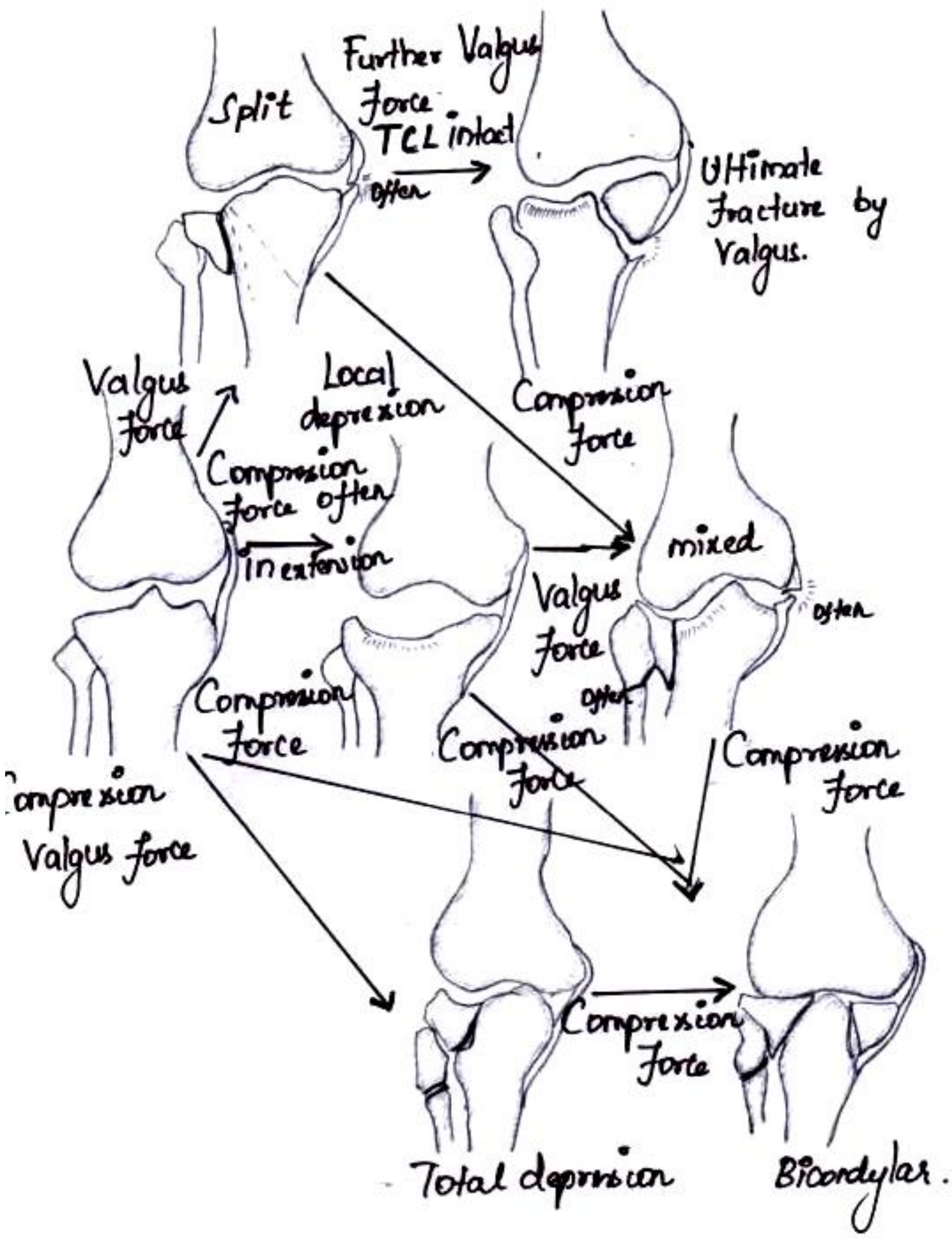
Lateral tibia plateau is more commonly involved than medial because anatomic axis of knee joint (7 degrees of valgus) causes a direct force from lateral to medial.

Age:

Elderly sustain depressed fracture more frequently because their subchondral bone is less likely to resist axially directed loads.

Younger individuals with denser subchondral bone are more likely to sustain cleavage type fractures and have an associated ligamentous disruption.

MECHANISM OF INJURY



CLASSIFICATION

- It allows the surgeons to consistently and reliably grade the fracture pattern into one of the groups.
- To decide the optimal method of treatment for the injury
- Able to tell the prognosis of injury pattern and functional outcome.

Classification system used for fractures of tibial plateau fractures include

1. Schatzker's classification,
2. AO classification,
3. Moore
4. Hohl and Moore

The Schatzker's classification is the widely accepted classification of tibial plateau fractures and it has been proven to be superior to other classification systems[23].

AO Classification:

The Arbeitsgemeinschoft Osteosynthese Fragen (AO) classification is divided into three main categories and is most useful as a research tool.

Type A fractures are extraarticular.

Type B fractures are partially articular and are subdivided into three main categories:

B1 fractures are pure splits,

B2 fracture are pure depression, and

B3 fractures are split depression.

Type C fractures are complete articular fractures and are also subdivided into three subtypes:

(a) being articular and metaphyseal simple,

(b) articular simple and metaphyseal multifragmentary, and

(c) articular multifragmentary

Fracture Classification (Schatzker) [6]:

Type I—pure cleavage. A typical wedge-shaped uncomminuted fragment is split off and displaced laterally and downward. This fracture is common in younger patients without osteoporotic bone.

Type II—cleavage combined with depression. A lateral wedge is split off, but in addition the articular surface is depressed down into the metaphysis. This tends to occur in older individuals,

Type III—pure central depression . The articular surface is driven into the plateau. The lateral cortex is intact. These tend to occur in osteoporotic bone.

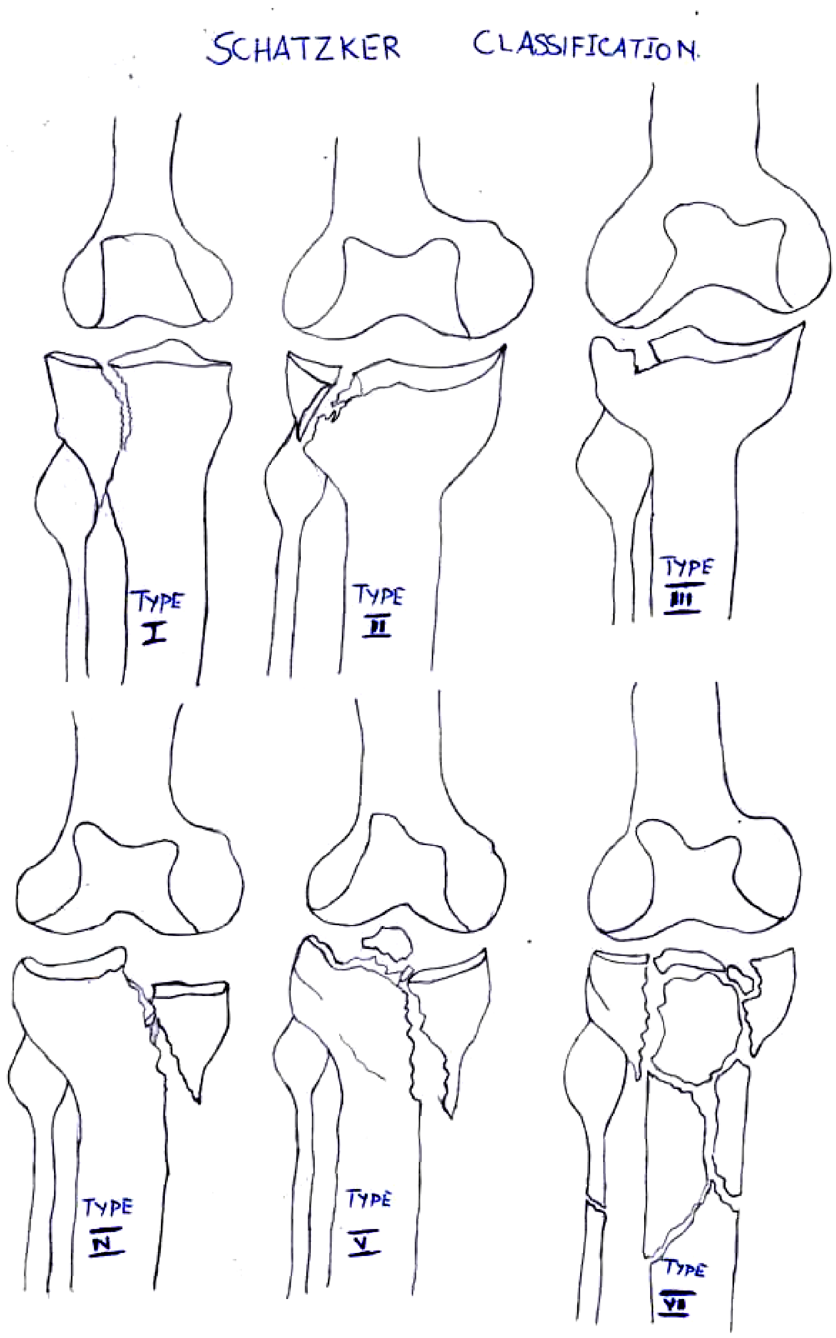
Type IV—fractures of medial condyle . These may be split off as a single wedge or may be comminuted and depressed. The tibial spines often are involved.

Type V—bicondylar fractures. Both tibial plateaus are split off. The distinguishing feature is that the metaphysis and diaphysis retain continuity

Type VI—plateau fracture with dissociation of metaphysis and diaphysis. A transverse or oblique fracture of the proximal tibia is present in addition to a fracture of one or both tibial condyles and articular surfaces.

Honkonen and Jarvinen have recently modified Shatzker's classification to take into account residual limb alignment. They divide type VI fractures into medially and laterally tilted fractures to take into account functional results in treated fractures with residual angulation [30].

SCHATZKER CLASSIFICATION



Hohl classification :

Undisplaced

Displaced

Local compression

Split fractures

Split compression

Total condyle depression

Communited fractures.

Fracture-Dislocation Classification (Hohl and Moore) [24] :

Type I—coronal split fracture of medial tibial plateau.

Type II—entire condyle fracture. This fracture-dislocation may involve the medial or lateral plateau with the fracture line extending into the opposite compartment beneath the intercondylar eminence

Type III—rim avulsion fracture. Associated with high rate of neurovascular injury.

Type IV—rim compression fracture. Associated with contralateral ligamentous injury.

Type V—four-part fracture. Tibial eminence is separated from the tibial condyles and tibial shaft.

SOFT TISSUE INJURIES[25]

Tibial plateau fractures are often associated with soft tissue injuries, hence they must be anticipated and looked for. They must be addressed as they affect the long term functional outcome of the knee [15].

It includes Menicsal injuries, Ligament injuries, Vascular injuries, Peroneal nerve injury.

Ligament injuries may be clinically suspected in patients with tenderness along the course of the ligaments. For confirmation stress testing under anesthesia and stress X rays may be taken. Surgical treatment depends on the degree of instability after fracture fixation. Cruciate ligament injuries are common in split compression fractures. Reports say ACL injuries occur in 23% of high energy tibial plateau fractures [25].

Incidence of meniscal injuries after plateau fractures is around 50% which has now increased with the advent of MRI and arthroscopy[27]. Irreparably damaged menisci are excised. Peripheral suturing or minor trimming is done in cases with minor injuries.

Popliteal artery is mostly injured at its bifurcation, the most fixed point. If ankle brachial index is less than 0.9 arteriogram is considered. Either direct trauma or stretch can damage the peroneal nerve.

DIAGNOSIS AND EVALUATION[26]

Tibial plateau fracture must be suspected in any patient who presents with knee pain following trauma or inability to ambulate and has tenderness over site of injury. History obtained gives us a good idea about the mode of injury, direction and velocity of force. Once the patient is suspected of having a tibial plateau fracture he must be thoroughly examined to rule out the presence of any associated injuries which may be life threatening. Thorough examination of the abdomen, chest, pelvis and skull is mandatory.

Vascular lesions are found in about 3%, nerve injuries in 1%.Meniscal tears occur in 50%[27] and associated lesions of cruciate and collateral ligaments occur in 30% of fractures. While associated fracture patella occurs in 15%.

Following initial management knee must be observed for the presence of hemarthrosis, and soft tissue injuries like superficial abrasion, deep contusion, hemorrhagic blisters, massive swelling, and skin wrinkling. The limb must be examined to rule out neurovascular compromise and compartment syndrome.

Investigation: X Rays AnteroPosterior, lateral, internal and external oblique, 15 degree caudal tilt view are generally needed. The degree of articular stepoff is determined on the 15 degree caudal tilt view[26]. Traction views may be needed for severe injuries.

Stress radiographs may be needed to rule out instability. Increase in width of 1mm of medial or lateral clears space is suggestive of collateral ligament injury during stress views. It is usually compared to the opposite leg. CT scans with 2mm cuts and axial, coronal and sagittal reconstructions best identifies fracture configuration, it is especially useful to assess articular depression[28]. It is also helpful in preoperative planning for placement of plates and screws. MRI scans are essentially useful to assess the extent of soft tissue injuries[29]. Studies have reported the incidence of meniscal and ligament injuries in tibial plateau fractures ranging from 47% to 97%. Arteriogram is useful when arterial injuries are suspected especially in high energy tibial plateau fractures.

PRINCIPLES OF MANAGEMENT

Many factors affect the management of these fractures.

They include,

1. Amount of fracture displacement
2. Degree of comminution
3. Extent of soft tissue injury
4. Associated neurovascular injuries
5. Magnitude of joint involvement
6. Degree of osteoporosis
7. Associated injuries
8. Complex ipsilateral fractures (e.g. patella/ Distal Femur fractures)

OBJECTIVES OF THE TREATMENT [26]

1. To obtain and maintain satisfactory fracture reduction and stable internal fixation.
2. To regain a functional range of motion of the knee joint
3. To regain the strength of quadriceps and hamstrings
4. To treat the associated injuries.

METHODS OF TREATMENT

The management of distal femur fractures can be divided into two broad categories.

1. **NON-OPERATIVE TREATMENT**
2. **OPERATIVE TREATMENT**

NON-OPERATIVE TREATMENT[4, 5]

Conservative treatment is indicated in undisplaced or minimally displaced, stable fractures .These can be treated by nonoperative methods like immobilization in long leg casts. Protected weight bearing and early range of knee motion in a hinged knee brace are also preferred by some authors. Only rarely displaced tibial plateau fractures are treated by skeletal traction .Disadvantages of casting include quadriceps atrophy and knee stiffness, moreover extended period of hospitalization and recumbency are not cost-effective in present day scenario. Historically conservative treatment of tibial plateau fractures has shown reasonable functional outcome.

OPERATIVE TREATMENT

The **absolute indications** for surgery are Open plateau fractures [33], those associated with compartment syndrome or vascular injury.

The **relative indications**[**6**, 24, 32] for surgery shall be Lateral plateau fractures with joint instability, Displaced medial condylar or bicondylar fractures, Articular depression (>2mm), > 10 degrees of varus, valgus instability, Multiply injured patients, Severe ipsilateral injuries, Associated ligament injury, Irreducible fracture, Pathological fracture.

The goals of operative treatment[26] are anatomical articular alignment, stable internal fixation, early mobilization, and early functional rehabilitation of knee.

Contraindications to internal fixation include active infection, severely contaminated open fracture, massive comminution (or) bone loss, severe osteopenia, inadequate facilities, inexperienced surgeons,

PROCEDURE

Sequences in the surgical management of tibial plateau fractures includes

Restoration of articular surface

Metaphyseal alignment

Impaction of fracture in osteoporotic patients

Early mobilization of knee

Prerequisites:

A radio-lucent operating table facilitates the use of an image intensifier during the procedure. Using fracture table is avoided because the resulting muscle tension will make exposure and reduction more difficult. A sterile bolster is placed under the knee to facilitate exposure and reduction. A sterile tourniquet may be used as a part of the procedure.

Reduction techniques: Reduction of the displaced fracture fragments can be done by either direct or indirect methods.

Direct method is by open reduction [6, 31, 34] techniques**.**

Indirect reduction is by using the principles of ligamentotaxis[35] or by creating a cortical window and elevating the articular fragments by using a tamp and filling the defect created with bone graft or bone substitutes. Indirect reduction techniques have the advantage of minimal soft tissue stripping and fragment devitalization.

PREFERRED TREATMENT[6]

Type V: Historically, these [bicondylar] fractures were stabilized with medial and lateral plates or with a combination of limited internal fixation and external fixation .With the advent of locking plates, laterally placed plates with screws that lock to the plate creating a fixed angle construct provide enough stability to counteract forces seen by the medial tibial plateau This allows for less surgical dissection and a decrease in the incidence of soft tissue complications.

Type VI: It implies metaphyseal-diaphyseal dissociation. Often there is a split depression fracture of the lateral plateau or a fracture of the medial side, which is either a coronal split or the entire condyle. Following articular reconstruction, the articular segment is stabilized to the tibial shaft using a single plate, double plates, a single plate and a contralateral two-pin external fixator, or a thin-wire fixator. If the fracture is transverse, a single plate will suffice. Oblique fracture lines exiting the opposite cortex require a second plate or external fixator to resist shearing forces.

IMPLANT OPTIONS

Screws: Usually large fragment cancellous screws are used in cases of simple split fractures that are anatomically reduced by closed means or in the cases of depression fractures that are elevated percutaneously. In certain cases when joint fragments are avulsed by soft tissue attachments, lag screw fixation alone may be used.

Buttress plate: Function as a buttress against shear forces or to neutralize rotational forces. Due to the thin soft tissue envelope around the proximal tibia, use of thinner plates has been advocated. L plate allows more butressing without getting in the way of proximal fibula. DCP holes in the shaft accept 4.5 mm cortex screws, round holes in the slightly thinner head accomodate 6.5 mm cancellous bone screws.

Hybrid external fixator: Hybrid external fixation of proximal tibia fractures has 2 or 3 tensioned transfixion wires on a single ring stabilizing the periarticular segment and 3 half pins in the diaphyseal segment, with the ring connected to the half pins through a variety of frame options. This combines the advantage of thin wire control in the limited space near the joint with the ease of application of unilateral half pin fixation in the shaft.This is mainly used in fractures associated with significant soft tissue injuries and compound fractures. Advantages are that it allows early mobilization and weight bearing.

Ilizarov External fixator: These are generally knee spanning fixators using thin wires with or without olive beads. That makes use of indirect reduction techniques using the principle of ligamentotaxis. It is indicated primarily in open fractures,fractures with compartment syndrome, also in severely communited fractures with diaphyseal extension.The key is to place the pin or wire 10 to 14 mm below the articular surface to avoid penetration of the synovial recess posteriorly. Helps to minimize the development of septic arthritis from a pin tract infection.

Advantages: No soft tissue dissection. These frames can be dynamized during fracture healing, which may help if delayed or nonunion occurs in the metaphyseal regions. Provides excellent stability in cases where there is severe soft tissue or bony defect. Allows for correction if there is a malalignment or deformity. Arthroscopy assisted fixation of depressed tibial plateau fractures is now on the rise, even this relatively newer technique has its own advantages and disadvantages.

Locking compression plate:

These implants combine the principles of angular stable construct and compression plating. Its design and characteristics allow it to be used by a minimally invasive approach by using the principles of biological osteosynthesis. Now frequently being used in the treatment of complex tibial plateau fractures. Reduces the need for compressing the plate directly to a bony surface, preserves blood supply and reduces the need for plate contouring.

IMPLANT DESIGN AND PRINCIPLE [11]

Principles: The locking compression plate (LCP) combines locking screw option with regular plate screw fixation. It can be also be used as bridging plate in osteosynthesis. Since the LCP can be used as conventional open plating using only static compression with reduction clamps, as a pure internal fixator in biological plating using locking head screws, or as both combined, its versatility provides the surgeon with multiple variations. However pre operative planning and good understanding of biomechanical principles of osteosynthesis is needed to achieve good clinical outcomes and maximum benefits from the LCP system. In this method the fracture zone of fragmented fractures of a shaft or metaphysis remains undisturbed during surgery following realignment taking account of the axis, length, and rotation, and the bridging plate is anchored in the main fragments proximal and distal to the fracture. In this method where exact bone to bone reduction is not attempted the fracture heals by **secondary bone healing** rather than by primary osteonal healing. This secondary bone healing is the aim of treatment and not the undesirable side effect.

APPLICATION:

The locking compression plate can be used as a compression plate, a locked internal fixator, or a combination of both, depending on the patient's individual situation. The importance of the reduction technique and minimally invasive plate insertion and fixation relates to ensuring that bone viability is undisturbed. Primary importance is the application of principles.

LENGTH:

One of the most important steps in the application of locking compression plate is selection of plates of appropriate length. In the case of locking compression plate the ideal plate length can be determined by the plate span width and the plate screw density. Plate span width is the quotient of plate length divided by overall fracture length. This quotient should generally be more than 2-3 for comminuted fractures and higher than 8-10 in the case of simple fractures.

NUMBER AND POSITINING OF SCREWS:

Screw density is the quotient of screws inserted divided by number of plate holes. Ideally this value should be under 0.4-0.5. In Locking compression plates it is no longer possible to recommend a definite number of screws or cortices to be used in each fragment.

BICORTICAL OR MONOCORTICAL:

Anchorage in the proximal and distal fragments remains important.

Two monocortical screws should be the minimum for each main fragment, to keep the construct stable. For safety reasons, we generally recommend two to three screws per main fragment, Bicortical screws in each fragment does not improve the situation from the aspect of screw failure, but does improve that of the interface between screw and bone, and it is recommended that at least one of the screws in the main fragment should be a biocortical screw.

SCREW DIAMETER:

Axial pullout of the screws is determined by the outer diameter of the screw. An increase from 4.5mm (conventional cortical screw) to 5.0mm (Locking Head screw) provides already 70% holding force in a monocortical Locking Head screw (LHS) compared to a 100% of the holding force of a conventional bicortical 4.5mm screw.

LOCATION OF SCREW:

Dynamic loading tests have shown that, with an effective increase in the length of bone bridged**,** this leads to premature failure of the implant. It is recommended that in simple fractures with bone contact, one or two combination holes be left unused on each side of the fracture space, while in complex fractures with an extensive fragmented zone and resultant lack of bone, contact the holes closest to the fracture should be used. An aiming device (sleeve) should be used in all cases while drilling for the locking head screws as axial deviation of the direction of drilling by more than 5° causes impaired stability. In case of metaepiphyseal fractures, combination holes in the area of the joint allow anatomical realignment and internal fixation; the metaphyseal region can be served by a bridging osteosynthesis. The number of screws in the area of the joint depends solely on the object of refixation with interfragmentary compression.

TIMING OF APPLICATION:

In cases where both conventional screw and locking head screws are applied it is necessary to apply the Locking Head Screw after the conventional screw. If the conventional screw would be applied after the Locking Head

Screw, the screw bone interface would be overloaded and the screw would be worthless.

SHAPE OF PLATE:

In contrast to conventional plates, in locking compression plate exact adaptation of the implant to the bone surface is not necessary. **Bending** the locking compression plate in the area of the metaphysis, ensures less stress on the soft tissue and also leads to diverging directions of the screws, affording increased resistance of the osteosynthesis to detachment. **Preshaped plates** have several advantages: intraoperative shaping is not needed, plate systems themselves help in achieving anatomical reduction, and aiming sleeve devices help in insertion of the locking head screws.

COMBI HOLES

LOCKING SCREW

LOCKING COMPRESSION PLATE

COMPLICATIONS

Though the management of tibial plateau fractures has undergone a sea of changes with respect to the operative technique and implant design, complications do occur which may be a result of trauma per se or the surgical procedure.

Of Conservative treatment: include thromboembolic manifestations [5, 6] pneumonia, peroneal nerve palsy and pin tract infections for those treated with skeletal traction.

Of Operative treatment: may be early or late complications.

Early complications include

Infection: rates vary from 1% to 38% [34,5]. Sloughing of skin is a major risk factor for infection which depends on the severity of the initial injury, poor surgical timing and improper soft-tissue techniques with extensive osseous devitalization and use of bicondylar implants [36].

Thromboembolic manifestations [5] and deep vein thrombosis occur in 5 to 10 %.

Late complications include**:**

Malunion may be intraarticular because of inadequate reduction or loss of reduction with respect to the articular surface to the tibial shaft. Patients with malunions with residual varus or valgus of greater than 10Â° have been shown to have a higher incidence of poor long-term functional results [30].

Post Traumatic Arthritis: Posttraumatic arthrosis may result from the initial chondral damage or be related to residual joint incongruity[37] .Good functional results can be obtained in the face of poor radiographic results, however, and they may be due to the preservation of the meniscus and its ability to bear a substantial portion of the load of the lateral compartment [37].

Painful hardware sometimes may need hardware removal after 1 year.

Loss of fixation: Improper use of implants and the failure to use bone graft or bone graft substitutes adequately to buttress the articular surface may lead to loss of reduction or backout of hardware [6]

Non Union is rarely seen in type 6 fractures. Common in conservative cases than in surgically treated cases, owing in part to the rich blood supply to proximal tibia and the predominance of cancellous bone

Vascular Injuries: These are rare caused by direct laceration or contusion of the artery or vein by fracture fragments or indirectly by stretching leading to initimal damage.

MATERIALS AND METHODS

In this study, fifteen patients with tibial plateau fractures who presented to our casualty between May 2008 to September 2010 were studied. All were males primarily in the third and fourth decade (minimum 22 years to maximum 55 years). All the patients were victims of road traffic accidents. The patients were resuscitated and once they were hemodynamically stable, were clinically examined and assessed for associated injuries. Clinically the knee joint was evaluated for degree of soft tissue injury, vascular compromise, presence of compartment syndrome, any obvious ligamentous instability. Radiological examination of the knee joint was done. X rays of the knee involved knee joint were taken, Antero Posterior and Lateral views, whenever necessary oblique views were obtained. Traction X rays were taken if the fracture patterns were not clear on the initial radiographs Schatzker classification of tibial plateau fractures was used to classify fractures in this study. The fractures were initially stabilized with either above knee slabs or calcaneal pin traction. CT SCAN of the knee joint was done in select cases with excessive articular communition and depression to assess the fracture characteristics. MRI of knee was not done routinely.

Inclusion criteria:

The following cases were included in our study

1. Closed Schatzker type 5 tibial plateau fractures.
2. Closed Schatzker type 6 tibial plateau fractures.

Exclusion criteria:

1. Open fractures
2. Fractures with compartment syndrome
3. Fractures with vascular compromise
4. Schatzker type 1,2,3,4 tibial plateau fractures

11 cases were treated with minimally invasive technique through standard lateral approach and 4 cases with Open Reduction and Internal Fixation. These cases were taken for surgery from minimum of 7 days to maximum of 30 days after the injury. For all cases a minimally invasive approach was preferred, open reduction was done only for fractures where it was felt that accurate reduction was not possible through a minimally invasive technique, the primary reason for which being delay in taking up of cases for surgery.

Operative procedure: for minimally invasive percutaneous plate osteosynthesis [38, 39].

Under appropriate anesthesia the patients were taken up for surgery. In all the patients locking compression plate were applied through a minimally invasive approach.

Patient positioning: All the patients were operated in a supine position on a radiolucent table, with a sterile bolster was under the affected knee. The entire leg was prepared and draped free and tourniquet was not used. Under image intensifier with sustained traction, the fracture pattern was analysed and based on the degree of articular incongruity or depression indirect reduction techniques were applied, through a metaphseal window the depressed articular surface if needed was elevated using a bone punch. Once the articular congruity was attained reduction was maintained temporarily using a K-wire passed through the subchondral bone or using large fragment cannulated cancellous screws. In most of the cases single lateral locking compression plating was done. A transverse incision was made at the level just above the head of the fibula on the lateral tibial plateau, it was carried upto the periosteum. Locking plate of adequate length was selected and slid in the submuscular plane along the lateral surface of tibia, all the while sustained traction was maintained and reduction monitored under C-arm.

Locking screws were applied to the tibial condyles, a maximum of 2 to 3 screws were applied, in the lateral view the presence of posteromedial fragmention of the medial tibial condyle was looked for, if present the fragments were held using the screws from the lateral locking plate. In two of our cases it was still found displaced, hence a separate medial plate was used through a separate incision at posteromedial aspect of the knee joint[40]. Distally locking screws or cortical screws were used based on the fracture pattern and the need for any compression or not. The distal screws were applied only after ensuring perfect anatomical reduction as the locking compression plate does not provide dynamic compression. Principles of bridge plating were used and the fracture fragments were not disturbed during any stage of the surgery. In cases which had the fracture fragments displaced in an antero posterior manner a lag screw in the antero posterior direction was used to hold the fragments. Wounds were closed by mattress skin sutures. Sterile dressings applied.

Operative procedure for Open Reduction and Internal Fixation:

Under tourniquet control, an ‘L’shaped incision was made beginning at the level just above the head of the fibula on the lateral tibial plateau, it was carried down to the shin of tibia and inferiorly or a lateral parapatellar incision was used[42]. Arthrotomy was done to expose the joint and visualize articular reduction. In the former approach submeniscal ligaments were cut to expose the articular surface[41]. The entire fracture was exposed, and reduced. The plating technique is the same for rest of the procedure. These patients were immobilised in an above knee slab postoperatively.

BONE GRAFTING: Autologous iliac crest bone grafting was done in four cases. These cases had depression of the articular surface which was elevated intaoperatively and the resultant gap was filled with bone graft [6, 35].

IMPLANT USED:

In all the patients a stainless steel hockey stick shaped locking compression plate with combi holes was used. For two patients in whom a posteromedial plate was needed, we used a T shaped locking compression plate. For the condyles a 6.5 mm cancellous locking screws and for the shaft 4.5 mm cortical locking screws were used.

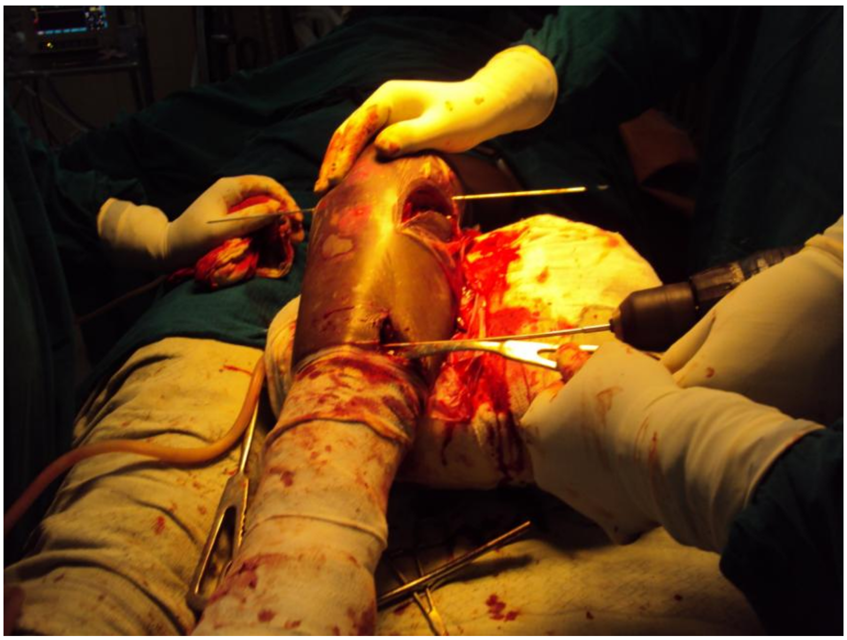
SURGICAL TECHNIQUE

PATIENT POSITIONING

SKIN INCISION

SLIDING THE PLATE

DELIVERING PLATE IN DISTAL WOUND

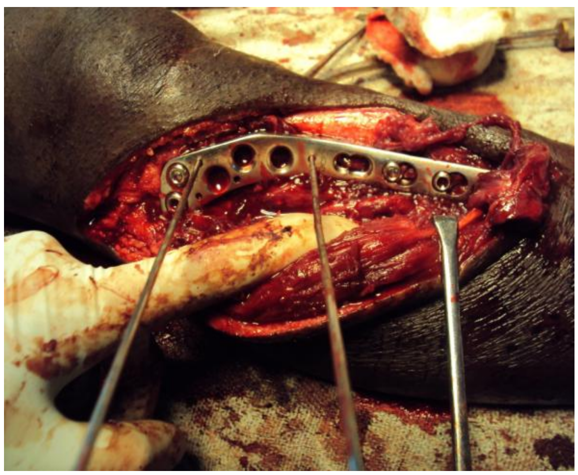


APPLICATION OF PROXIMAL SCREWS

APPLICATION OF DISTAL SCREWS

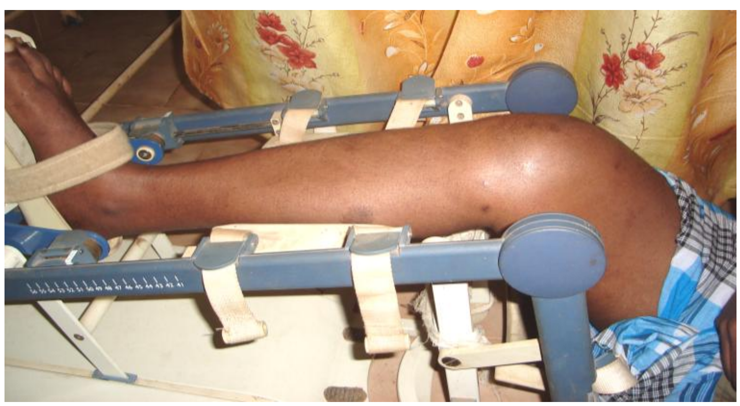
` SKIN CLOSURE

OPEN REDUCTION WITH IMPLANT IN SITU



IMPLANTS AND INSTRUMENTATION

PATIENT IS ON CPM



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POST OPERATIVE PROTOCOL AND REHABILITATION

All patients were started on broad spectrum intravenous antibiotics started preoperatively continued for four days postoperatively. Suction drain was removed 48 hrs after surgery .Emphasis was laid on starting early range of motion and static quadriceps exercises as Rasmussen [15] considered 6 weeks to be the upper limit of knee mobilization for restoring normal range of movements . Exercises were started on the second post operative day as per patient tolerance. Gentle hip and ankle mobilization exercises were initiated. Continuous passive motion was advised for select cases. Non weight bearing mobilization was started on the second postoperative day.

Follow up: All patients were reviewed at 4 weeks, 8 weeks and 12 weeks and once in two months thereafter. They were assessed for clinical and radiological signs of union. Clinically patients were observed for wound healing, fracture site tenderness, pain on weight bearing. Radio logically the patients were analyzed with x ray s at every post operative visit for evidence of articular incongruity, condylar widening and mal alignment.

Weight bearing was allowed after seeing the signs of union clinically and radiologically. Clinical union was defined as a painless fracture site during full weight bearing. Radiographic union was defined as bridging trabeculation across the fracture line(s) on three of four cortices. Functional outcome was measured using Bostman knee score[16] and radiological outcome using Rasmussen radiological assessment[15] uniformly for all the patients at 6 months follow up. Condylar depression was measured from a reference line level with the uninjured plateau. Condylar widening was obtained by measuring total width of tibial plateau just below the joint line and measuring the width of femoral condyles just above the joint line. These two measurements are normally equal [45].

Statistical methods

The data were expressed using descriptive statistics such as mean, standard deviation, frequency percentage etc. Comparison of continuous variable between groups (frequency, type, gender, method of surgery, functional outcomes etc) was done using independent sample t test, ANOVA. Categorical variables were analyzed using chi square test for their significant association. $P < 0.05$ was considered statistically significant.

OBSERVATIONS AND RESULTS

The cases were analyzed as per the following criteria:

1. AGE DISTRIBUTION

The group varied from 22 to 55 years with the mean age of 36.5 years

Incidence of fracture was observed maximum between 31 to 40 years of age.

Age Group	Number of cases	Percentage
21-30 years	5	33.33
31-40 years	7	46.67
41- 50 years	2	0.13
51- 60 years	1	0.067

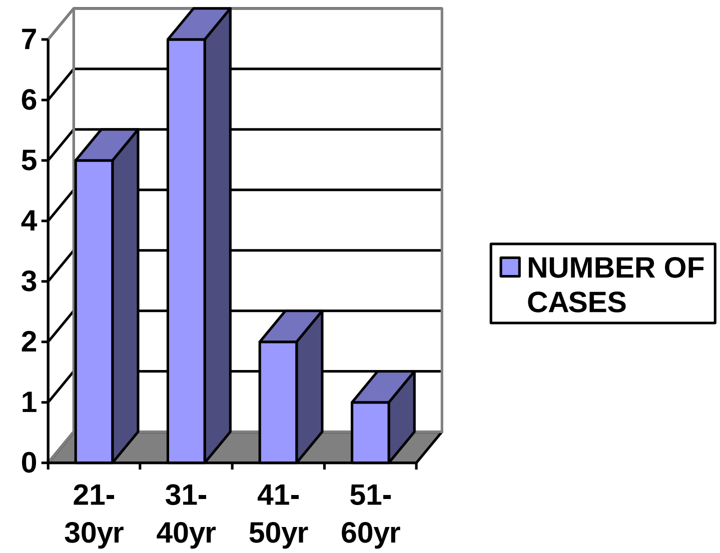
2. SEX DISTRIBUTION: all the cases in our study were males

3. SIDE OF INJURY

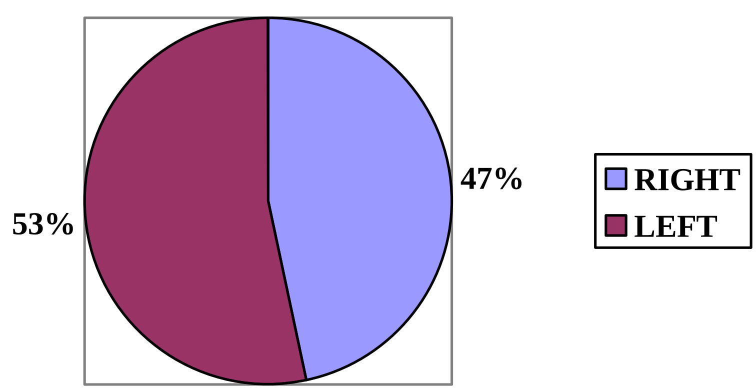
Both side were equally involved in our study

Sex	Right	Left	Total
Male	7	8	15
Percentage	46.6 %	53.4%	100%

AGE DISTRIBUTION



PERCENTAGE OF SIDE INVOLVED



4. MODE OF INJURY:

Road traffic accident was the commonest mode of injury.

5. TYPE OF FRACTURE (SCHATZKER):

There was no preference with respect to the type of fracture, with both types being equally involved.

6. TIME OF UNION:

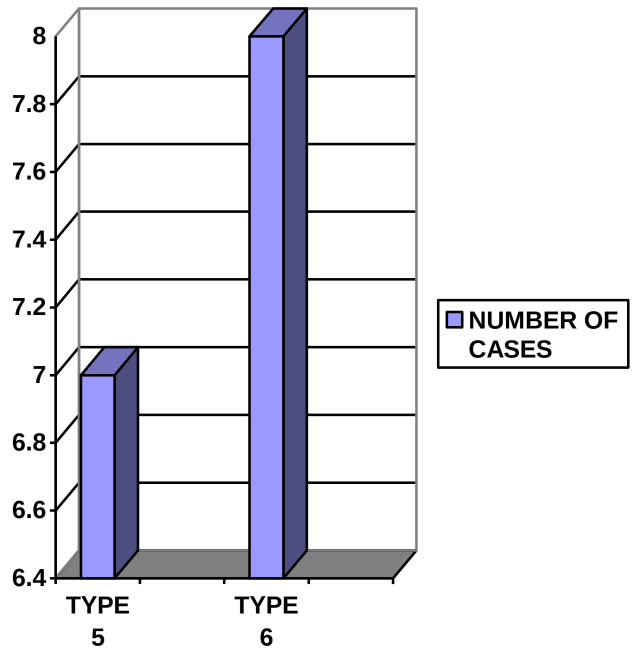
The time of union varied from minimum of 12 weeks to a maximum of 24 weeks with the average being 15.2 weeks.

7. ASSOCIATED INJURIES:

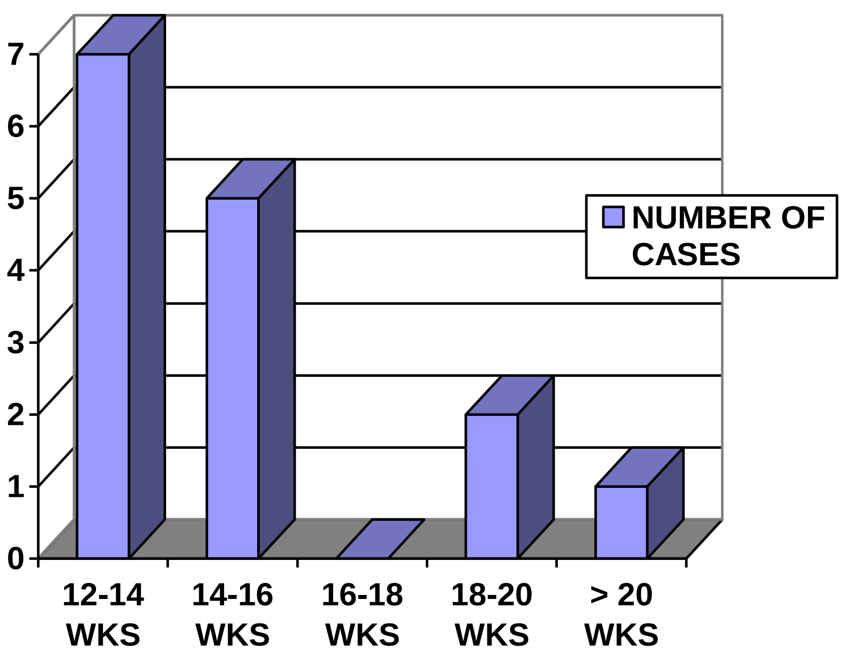
Fracture neck of femur	1
Fracture shaft of femur	2
Splenic injury	1

8. Follow up: The follow up period ranged from a minimum of 4 months to a maximum of 24 months. Average being 11.26 months.

TYPE OF FRACTURE (SCHATZKER)



TIME FOR UNION



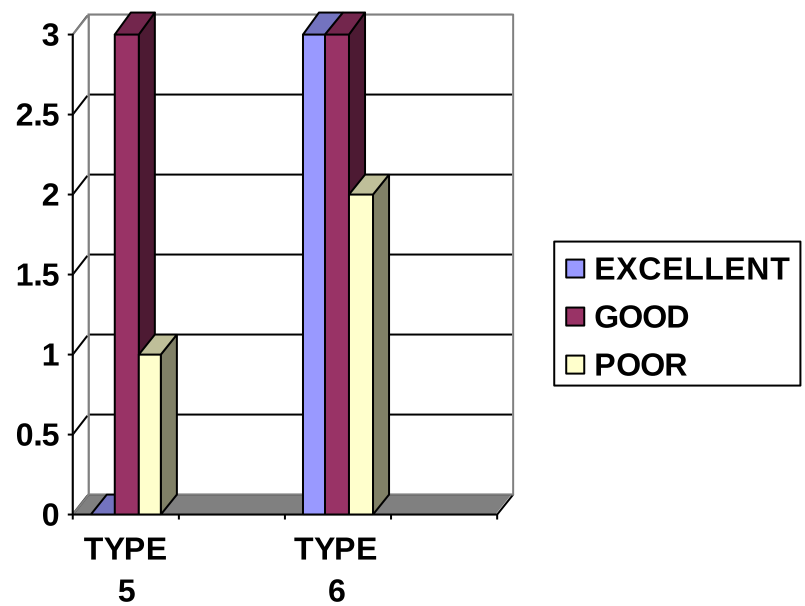
CASE DISTRIBUTION ACCORDING TO FUNCTIONAL OUTCOME

	No of cases	**Percentage**
Excellent	6	40
Good	6	40
Poor	3	20

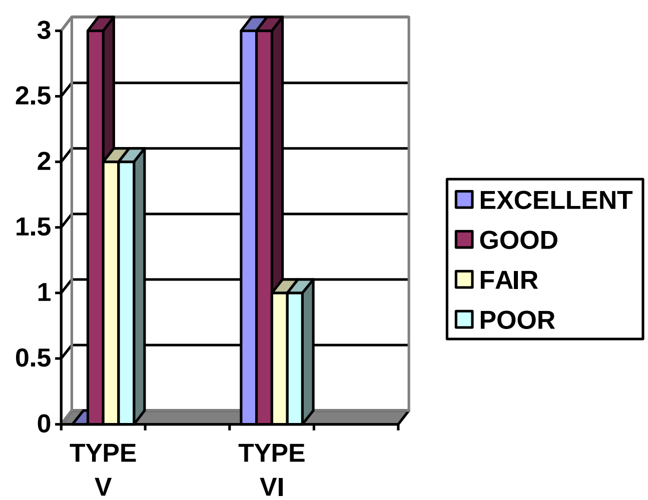
CASE DISTRIBUTION ACCORDING TO RADIOLOGICAL OUTCOME

	No of cases	**Percentage**
Excellent	3	20
Good	7	46.7
Fair	3	20
Poor	2	13.3

FUNCTIONAL OUTCOME ACCORDING TO FRACTURE SUBTYPE



RADIOLOGICAL OUTCOME ACCORDING TO FRACTURE SUBTYPE



COMPARISON BETWEEN OPERATIVE TECHNIQUES

ACCORDING TO TIME OF UNION

	MIPPO	ORIF	Overall
AVERAGE TIME FOR UNION wks	13.9	18.75	15.2

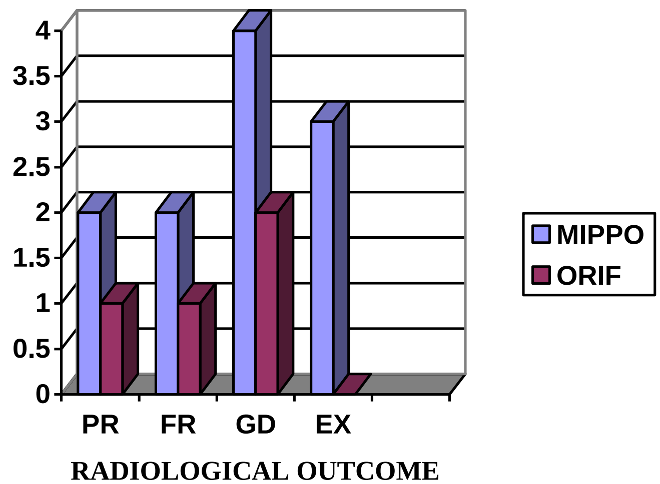
ACCORDING TO FUNCTIONAL OUTCOME

	MIPPO	ORIF	Overall
AVERAGE SCORE	26	14.75	24.46

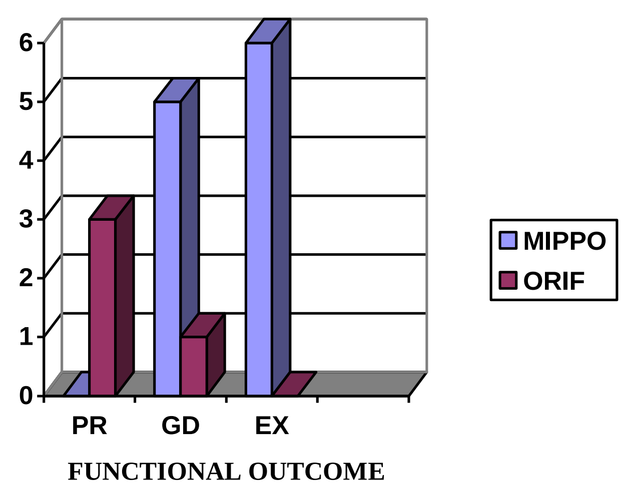
ACCORDING TO POST OP KNEE MOVEMENTS

	MIPPO	ORIF	Average
AVERAGE RANGE OF MOTION degrees	117.3	85	101.15

RADIOLOGICAL OUTCOME ACCORDING TO OPERATIVE TECHNIQUE



FUNCTIONAL OUTCOME ACCORDING TO OPERATIVE TECHNIQUE



COMPARISON OF FUNCTIONAL OUTCOME BETWEEN MIPPO AND ORIF

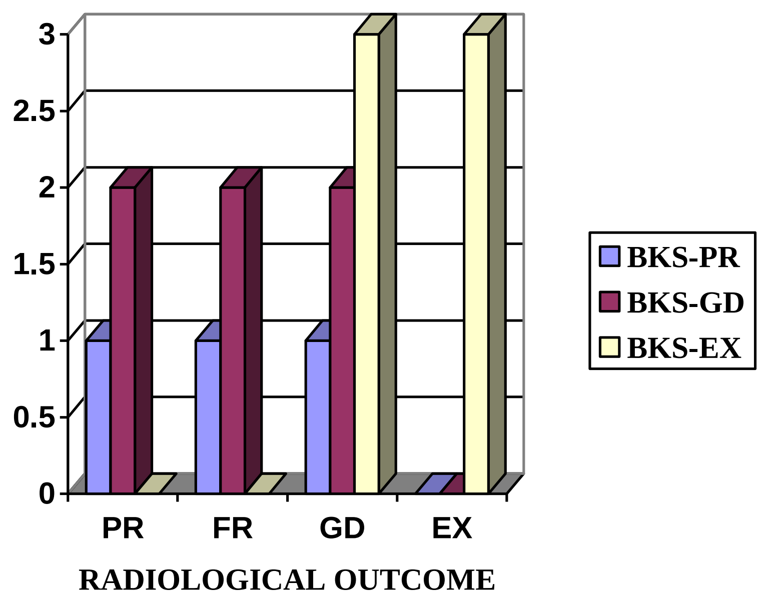
	MIPPO	ORIF
EXCELLENT	6 (100%)	0
GOOD	5(83.3%)	1(16.7%)
POOR	0	3(100%)

COMPARISON OF RADIOLOGICAL OUTCOME BETWEEN MIPPO AND ORIF

	MIPPO	ORIF
EXCELLENT	3(100%)	0
GOOD	5(71.4%)	2(28.6%)
FAIR	2(66.6%)	1(33.33%)
POOR	1(50%)	1(50%)

Maximum Rasmussen radiological assessment score was 18 and the minimum was 6, with an average of 12.

RADIOLOGICAL OUTCOME IN PATIENTS WITH DIFFERENT FUNCTIONAL OUTCOMES



COMPLICATIONS IN OUR STUDY

Infection: 3 case developed wound infection, of which 2 were superficial infection controlled by appropriate antibiotics and regular dressings. One case developed wound necrosis which needed regular dressings and debridements and healed by secondary intention.

Knee stiffness: 3 of our cases were developed knee stiffness with the range of motion being less than 90 degrees. They were advised active and assisted range of motion exercises for knee joint.

Malunion: In one case where there was more than 20 degrees of varus angulation.

Limb length discrepancy: Shortening of around 1 cm was observed in one case, which had associated fractures of femur.

COMPLICATIONS

KNEE STIFFNESS

SECONDARY LOSS OF REDUCTION

SKIN NECROSIS

MALUNION

ILLUSTRATED CASES

CASE 1

A 55 year old male postmaster presented to us two days following a bike accident with his left leg immobilized on an above knee slab. On bi valving the slab he had blisters over proximal tibia, with swelling and tenderness. No evidence of compartment syndrome or compromised vascularity. Limb was splinted, treated with daily dressings and antibiotics.

X rays revealed a Schatzker type 6 tibial plateau fracture. After anesthetic assessment patient was taken up for surgery .Treated by dual plating for both condyes by Minimally Invasive Plate Osteosynthesis. Post operative period was uneventful. Follow up showed union at 12 weeks with full range of movements and no complications.

Bostman knee score – 30 (excellent).

Rasmussen radiological assessment – 18 (excellent)

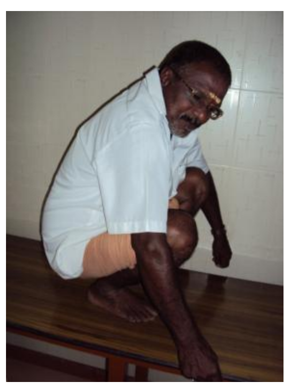
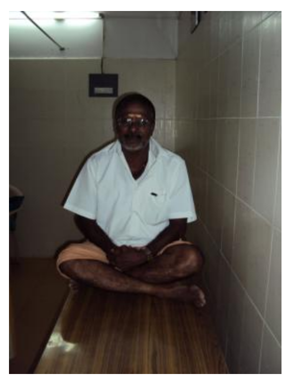
CASE 1 PRE OPERATIVE X RAYS



IMMEDIATE POST OP 6 MONTHS POST OP



FUNCTIONAL OUTCOME

CASE 2

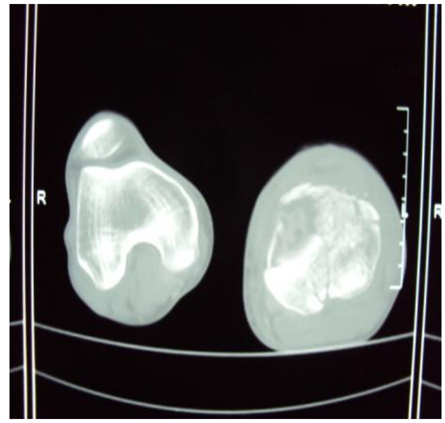
Forty year old male, presented to casualty following a road traffic accident, in a state of hemodynamic shock. He was revived with emergency blood transfusion and supportive measures. Primary survey revealed that he had a blunt injury abdomen with associated injury to the knee on the left side. X rays showed Schatzker type six tibial plateau fracture. He was taken for emergency laparotomy, intraoperatively he had splenic rupture for which splenectomy was done. Post operative period was uneventful. All the while he was immobilized in an above knee slab. Patient was taken up for orthopaedic management after two weeks. Fracture fixed with locking compression plate by Minimally Invasive Plate Osteosynthesis. Post operatively he had superficial wound infection at the entry site which settled with antibiotics and dressings.

Follow up: fracture united in 16 weeks. He had full range of movements. But had pain in day to day activities. Radiologically he had around 10^{o} valgus angulation. Still had good functional outcome.

Bostman Knee Score -22 (GOOD),

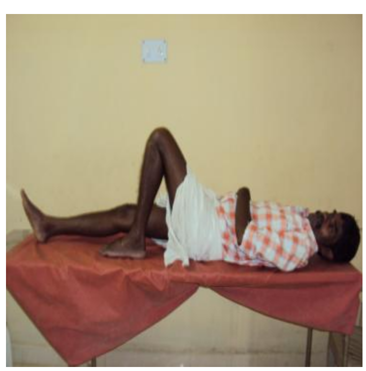
Rasmussen Radiological Assessment - 14 (GOOD).

CASE 2 PREOPERATIVE X RAYS CT SCAN



IMMEDIATE POST OP 6 MONTH POST OP

FUNCTIONAL OUTCOME



CASE 3

Thirty eight year old lorry driver who presented immediately after a road traffic accident.

X rays revealed a type 6 tibial plateau fracture, Patient was taken up for surgery after ten days. Fixation done by Minimally Invasive Plate Osteosynthesis using a single lateral locking plate. Post op period was complicated by superficial wound infection, which was treated with sensitive antibiotics and antiseptic dressings.

Follow up: wound healed well.

Time for union – 13 weeks. Patient regained full range of movements.

Bostman Knee Score - 30 (Excellent)

Rasmussen Radiological Assessment - 18 (Excellent).

CASE 3 PRE OP X RAYS

IMMEDIATE POST OP 6 MONTHS POSTOP

FUNCTIONAL OUTCOME

CASE 4

Forty year old agricultural labourer presented to our casualty with polytrauma following a road traffic accident. Following initial resuscitation radiographs showed that he had a fracture neck of femur, fracture shaft of femur and schatzker type 6 tibial plateau fracture all on the right side. He was immobilized in a bohler braun splint with a calcaneal pin traction. Patient was taken up for surgery only after 3 weeks due to delay in getting anesthetic assessment. We performed an Open Reduction Internal Fixation with cannulated cancelous screws for neck of femur, Open Reduction Internal Fixation with Broad DCP for shaft of femur, Open Reduction Internal Fixation with single lateral locking compression plate for tibial plateau fracture. All were performed in single stage.

Postoperatively all wounds healed well.

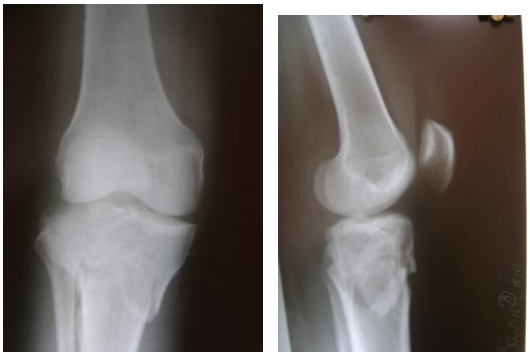
Follow up: patient had knee stiffness with 80 degrees of flexion. With pain in day to day activities and needed ambulation assistance.

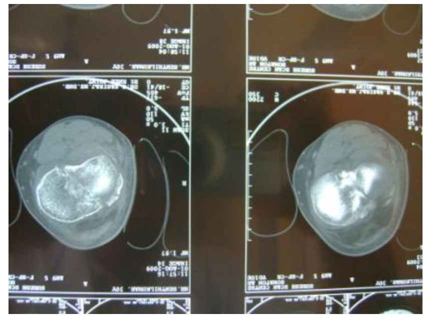
Union was delayed taking 24 weeks,

Bostman Knee Score – 8 (Poor)

Rasmussen Radiological Assessment – 10 (Fair).

CASE 4 PRE OP X RAYS CT SCAN





IMMEDIATE PRE OP 6 MONTHS POST OP

FUNCTIONAL OUTCOME

CASE 5

38 year old office clerk had a Schatzker type 6 tibial plateau fracture on his right side following a road traffic accident, which was initially immobilized in an above knee slab. Patient was taken up for surgery after one week. Surgery done by Minimally Invasive Plate Osteosynthesis, with single lateral locking compression plate.

Postoperatively the wound healed well with no other complications. Patient was followed up for a period of 24 months. Clinical and radiological union was achieved in 12 weeks, with full range of movements.

Functional and Radiological outcome was excellent.

Bostman Knee Score being 30, and the

Rasmussen Radiological Assessment being 18.

CASE 5 PRE OP X RAYS

IMMEDIATE POST OP 6 MONTHS POST OP

FUNCTIONAL OUTCOME

DISCUSSION

This prospective study done on fifteen patients with high energy tibial plateau fractures gives us an insight into the epidemiological pattern of these injuries. In our series the patients were predominantly in the fourth decade followed by five men in the third decade. Interestingly all our patients were males, no females were admitted with upper tibial fracture during the study period. There was no preference to the side involved and between type V and type VI they share equal percentage of these cases.

There was an increased incidence of associated injuries in our series ranging from fracture shaft of femur, fracture neck of femur to splenic injuries giving testimonial to the high velocity of these injuries.

Average waiting period for surgery was 14.33 days. There is significant association between lag period and functional outcome (p 0.007) with cases operated early having better functional outcomes.

In our series all the patients were operated using MIPPO technique except four of these patients who presented very late and ended up with open reduction and internal fixation. Late cases which underwent open reduction internal fixation in an attempt to achieve joint congruity went in for complications like knee stiffness, wound necrosis and poor functional outcomes. But there was no significant association between the operative technique and complications (p 0.428). In cases operated by minimally invasive technique there was no use of tourniquet and blood loss was minimal varying from 30 to 50 ml, whereas in open reduction methods tourniquet time varied 1 to 1½ hours and the average blood loss was around 150 to 200ml which reiterates the advantages of minimally invasive approach over open reduction.

Most of the good range of movements came from minimally invasive methods. However two cases of MIPPO had poor range of movements, first taken up for surgery after three weeks and the other where there was a secondary loss of reduction needing prolonged immobilization.

During the follow up period which ranged from four months to twenty four months average being 11.26 months, the cases were assessed for functional outcome using Bostman knee score which took cognition of the activities of daily living with clinical findings like pain, effusion, instability, range of movements and we had 6 excellent, 6 good and six poor cases. The patients in whom Minimally Invasive Plate Osteosynthesis was used showed better results when compared to Open Reduction Internal Fixation with the average functional score being 26 in the earlier and 14.75 in the latter. Thus cases operated by minimally invasive techniques have better functional outcomes compared to those treated by open reduction (p value 0.001) proven by both ANOVA and chi square tests. All the patients [3] with poor results belonged to the Open Reduction Internal Fixation group, one case was a polytrauma patient with multiple injuries to femoral shaft and neck. Second case was a gentleman taken up for surgery after one month with excessive articular communition and depression. The third case developed postoperative wound necrosis treated with debridement and regular saline dressings. Patients were radiologically assessed using Rasmussen scoring system and we had 3 excellent, 7 good, 3 fair and 2 poor outcomes with an average Rasmussen score being 12,which is comparable to results obtained by Mathur et al[43] (average score 15.3). With respect to the analysis of radiological outcome there is no association of it with the operative technique (p 0.714). And reiterating the fact that radiological outcomes do not alter the functional outcomes, it has been found that there is no association between the two (p 0.188). Though Schatzker type 6 is supposed to be prognostically bad compared to type 5, there was no significant association between the type of fracture and functional and radiological outcomes (p 0.875, p 0.306). More than the type, early surgery and closed treatment held the key to good results. In spite of the often feared complication of non union in locking compression plates, in our study all the cases ended in bony union.

Statistical analysis has proved that there is significant difference in duration of fracture union between minimally invasive groups and open reduction groups with the former showing union earliest (p value 0.019). Malunion occurred in a one case which had poor functional outcome primarily due to poor patient compliance. In a series by Mathur et al [43]on 27 operatively treated tibial plateau fractures, functional outcome was analyzed using Rasmussen scoring and they obtained 37% excellent and 51.85% good results with only 3 patients having unacceptable results. Whereas in our study the average functional score was 24.46 (range 8- 30) with 40% having excellent, 40 % having good and with rest having poor functional outcomes. The mean Rasmussen's radiological score at final follow up was 15.33 (range, 10-18), in our study the average radiological score was 12 (range 6-18) ,they had also observed clinical evaluation did not correlate with the follow up radiograph as the same in our study. Though Mathur et al[43] in their series had used the open reduction techniques advocated be AO/ASIF, from our results we see that minimally invasive methods also achieve equally good results.

In an other study by Kienast et al[44] on the use of unilateral lateral locking plates in bicondylar tibial plateau fractures in twenty six patients , he achieved 65% good, 23% moderate and 11% poor results, which is comparable to our study. The average postoperative knee movements in our study were 101.15 degrees with three patients having movements less than ninety degrees similar to Kienast et al. In our series the infection rate was less limited to superficial wound infection in one case and wound necrosis in an other all of which settled by regular dressings and antibiotics. Historically the rate of infection following dual incision techniques for tibial plateau fractures has been high sometimes going up to 50% in some studies[6,34], but in our study the rate of infection was only 20 % in which two cases were superficial infections. As far as the complications are concerned they do not alter the functional and radiological outcomes (p 0.374, p 0.498).

Our study confines to a group of 15 patients followed up for a mean period of 11.26 months.

CONCLUSION

Early stable fixations of the bicondylar fractures of tibial plateau by biological methods using locking compression plates achieve acceptable results.

The minimally invasive approach is a boon in the treatment of such complex fractures as it achieves early union ,good functional outcome and minimal complication.

With emphasis now shifting from perfect reduction and rigid fixation to biological means of fixation by minimally invasive approaches.

To achieve the above goals we need an implant which provides stability at the same time respects biology, for which locking compression plate is the answer.

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ANNEXURE

I.BOSTMAN KNEE SCORE

VARIABLE	POINTS (MAXIMUM 30)
1. Range of motion	
Full extension and range of motion > 120 degrees or < 10 degrees of normal	6
Full extension, motion 90 to 120 degrees	3
Flexion < 90 degrees	0
2. Pain	
None or minimal on exertion	6
Moderate on exertion	3
In daily activities	0
3. Work	
Original job	4
Different job	2
Cannot work	0
4. Atrophy, difference of thigh circumference 10 cm proximal to patella	
< 12 mm	4
12 – 25 mm	2
> 25 mm	0
5. Ambulation assistance	
None	4
Cane part time	2
Cane full time	0
6. Effusion	
None	2
Reported to be present	1
Present	0
7. Giving away	
No	2
Sometimes	1
Daily life	0
8. Stair climbing	
Normal	2
Disturbing	1
Disabling	0

EXCELLENT 28 – 30 POINTS

GOOD 20 – 27 POINTS

POOR < 20 POINTS

II. RASMUSSEN RADIOLOGICAL GRADING.

Radiological assessment was done using RASMUSSEN radiological grading.

	Points	Excellent	Good	Fair	Poor
1. Depression Not present < 5 mm 6 to 10 mm > 10 mm	6 4 2 0	6	4	2	0
2. Condylar widening Not present < 5 mm 6 to 10 mm > 10 mm	6 4 2 0	6	4	2	0
3. Angulation (varus/valgus) Not present < 10 degrees 10 to 20 degrees > 20 degrees	6 4 2 0	6	4	2	0
Total		18	12	6	0

III. CLINICAL PROFORMA

Name: Age/sex: IPNO:

Hospital: Unit : Ward:

Address:

Phone No:

Date of Admission:

Date of Surgery:

Date of Discharge:

Diagnosis:

Operative Procedure:

Clinical Features:

Associated Injuries:

Investigations:

1. Radiograph 2.CT/MRI
3. Blood investigations 4.Chest X-Ray
5. ECG 6. Others

Post op advice:

Follow up:

4 weeks 12 weeks 16 weeks

Complications:

Functional score:

Radiological score:

IV. CONSENT PROFORMA

Title: A study on closed tibial plateau fractures managed with the locking compresssion plating.

Aim: The aim of our study is to find the functional outcome of locking compresssion plating in the Management of tibial plateau fracture (schatzker type v and vi)

Consent: I have been explained about the nature of injury, method of treatment, potential complications, the outcomes of not undergoing the surgery, and need of regular follow up visits in my own vernacular language

I hereby give my consent for this study.

Signature

MASTER CHART

SNo	Name	Age	sex	Side	Schatzker Type	Lag in days	Associated injury	Technique	TQ hr	BL loss in ml	POST OP ROM	Union week	Complications	Follow up mnths	BKS	RRA	BKS outcome	RRA Outcome
1	M1	38	M	R	VI	7	nil	MIPO	-	30	0-130	12	NIL	24	30	18	EX	EX
2	R1	55	M	L	VI	7	blister	MIPO	-	30	0-130	12	NIL	24	30	18	EX	EX
3	G1	38	M	R	VI	10	nil	MIPO	-	30	0-130	13	SUP- INF	18	30	18	EX	EX
4	S1	40	M	R	VI	21	SOF/ NOF	ORIF	1½	200	0-90	24	NIL	12	8	10	PR	FR
5	M2	40	M	L	VI	15	Splenic	MIPO	-	30	0-130	16	SUP INF	6	22	14	GD	GD
6	S2	30	M	L	VI	14	nil	MIPO	-	30	0-70	20?	LOSS OF RED	6	20	6	GD	PR
7	G2	45	M	L	V	14	nil	MIPO	-	30	0-110	12	NIL	12	22	10	GD	FR
8	A	24	M	L	V	30	nil	ORIF	1 ½	150	0-90	16	NIL	4	16	6	PR	PR
9	R2	34	M	R	VI	21	nil	ORIF	1	150	0-100	15	NIL	5	20	12	GD	GD
10	D	38	M	R	V	7	nil	MIPO	-	30	0-130	12	NIL	14	28	14	EX	GD
11	C1	28	M	L	V	10	SOF/	MIPO	-	45	0-110	16	NIL	10	27	10	GD	FR
12	C2	22	M	L	V	21	nil	MIPO	-	45	0-90	16	NIL	9	20	6	GD	PR
13	G3	40	M	L	V	14	nil	MIPO	-	30	0-130	12	NIL	11	28	12	EX	GD
14	S3	29	M	R	V	10	nil	MIPO	-	30	0-130	12	NIL	6	29	14	EX	GD
15	P	46	M	R	VI	14	nil	ORIF	1 ½	150	0-60	20	WOUND NECROSIS	8	15	12	PR	GD

Abbreviations used in master chart

MIPPO - minimally invasive percutaneous plate osteosynthesis

ORIF - open reduction internal fixaton

BL - blood loss

RED - reduction

GD - good

PR - poor

TQ - tourniquet

EX - excellent

FR - fair

SOF - shaft of femur

NOF - neck of femur

SUP-INF - superficial infection